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Growth and Development Symposium: Fetal programming in animal agriculture[1]

R. A. Hill,*[2] E. E. Connor,† S. P. Poulos,‡ T. H. Welsh,§ and N. K. Gabler#

*Department of Animal and Veterinary Science, University of Idaho, Moscow 83844-2330; †USDA-ARS, Beltsville Agricultural Research Center, Beltsville, MD 20705; ‡The Coca-Cola Company, Research and Technology, Atlanta, GA 30313; §Departments of Animal Science & Veterinary Integrative Biosciences, Texas AgriLife Research, Texas A&M University System, College Station 77843-2471; and #Department of Animal Science, Iowa State University, Ames 50011

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The ability to improve animal production and well-being by altering the maternal environment holds enormous challenges and great opportunities for researchers and animal industries. The concept known as fetal programming, developmental programming, or fetal developmental programming is not a new one. The theory was originally developed using epidemiological data from humans, which showed that in utero and postnatal environmental experiences (i.e., nutrition, disease, and stress) during critical times of early development can have profound long-term effects on development, growth, and disease risk (Barker, 1995). However, animal agriculture has been slow to fully embrace the concept of fetal programming to improve animal growth, development, and well-being. Thus, the joint Annual Meeting of the American Society of Animal Science, the American Dairy Science Association, and the Canadian Society of Animal Science, held in Montreal, Québec, Canada, on July 12 to 16, 2009, provided the ideal forum for a symposium aimed at providing an overview of current knowledge of fetal programming in relation to the animal sciences. Particular emphasis was placed on muscle tissue, milk supply, and reproduction across agriculturally important species.

The first paper presented in this symposium by Blair et al. (2010) addresses 2 sheep studies conducted in New Zealand. The first compared the effects of dam nutrition (maintenance or 1.5 times maintenance) during pregnancy on fetal growth and organ size, and the second examined whether fetal mammary gland differences found in the first study are repeatable, and whether these differences in fetal mammary tissues translated into differences in milk production. Although the first study reported no differences in fetal weights, changes were observed in fetal mammary development. These findings led to the hypothesis that offspring from ewes fed at restricted (i.e., maintenance) levels during early to mid pregnancy may have compromised lactational capabilities. To test this hypothesis, a second study followed the performance of offspring of heavy and light BW ewes fed at maintenance or ad libitum. Blair et al. (2010) concluded that despite decreased ewe BW at maintenance-feeding levels during pregnancy, fetal mammary gland weights were greater in the maintenance group relative to the ad libitum-fed group. The ewes whose dams were fed at maintenance levels during pregnancy also produced greater protein and lactose yields in their first lactation compared with ewes whose dams were fed ad libitum during pregnancy. Furthermore, the grand-offspring of ewes fed at maintenance had increased birth weights compared with the ad libitum-fed grand-offspring. Thus, it appears that lactation can be affected by the level of feed that dam of a ewe received during pregnancy and early development. However, it is not clear whether these effects are caused by in utero mechanisms, by consequent changes in the lactation of the dam, or by epigenetic processes.

Second, the importance of the maternal environment on myogenesis and muscle fiber number development on subsequent postnatal growth in livestock was realized in the 1980s (Wigmore and Strickland, 1983; Handel and Strickland, 1987). Therefore, the next symposium paper in this series provides a review of recent progress in the field of fetal programming of bovine skeletal muscle myogenesis, intramuscular adipogenesis, growth performance, and meat quality of offspring in beef cattle (Du et al., 2010). In addition to providing an excellent overview of the molecular development of muscle and adipose tissue, Du et al. (2010) also discuss how the fetal stages of development provide a unique and, perhaps, the best window of opportunity for nu-

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[2]Corresponding author: rodhill@uidaho.edu

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tritional management and manipulation, which can exert long-term effects on the growth performance of offspring. During fetal development, an abundant pool of pluripotent cells exists in fetal muscle, which is exposed to nutrients derived from the maternal circulation. This indicates manipulating maternal nutrition may allow for the potential promotion of myogenesis or adipogenesis in fetal muscle.

The final symposium paper presented in this series, Reynolds et al. (2010), discusses various large animal models of developmental programming and how they have contributed to our understanding of the mechanisms underlying altered placental function and developmental programming. Additionally, Reynolds et al. (2010) highlighted how large animal models are critical to the identification and application of therapeutic strategies to alleviate the negative consequences of developmental programming for human medicine and animal production.

In animal and biomedical science, there is growing evidence that fetal programming can alter postnatal development, growth, and disease susceptibility. Although the mechanisms by which the maternal environment regulates fetal programming are poorly understood, rapid advances in identifying environmental markers that alter epigenetic regulation of fetal and postnatal gene expression provide a new frontier for interdisciplinary research. This research could be used to manipulate the prenatal environment to exert profound improvements in animal health and well-being and to increase animal production efficiency. In addition, animal models can aid in understanding the role of in utero environment and epigenetic regulation in human health and well-being.

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